

What is claimed is:

1. A semiconductor device comprising:
  - a substrate;
  - a first insulating film formed on the
  - 5 semiconductor substrate;
  - a semiconductor layer at least a part of which
  - is formed on the first insulating film;
  - a second insulating film comprising a non-doped
  - silicon oxide film and formed on the semiconductor layer;
  - 10 a third insulating film comprising a silicon
  - oxide film containing at least phosphorus formed on the
  - second insulating film; and
  - a fourth insulating film comprising a non-doped
  - silicon oxide film formed on the third insulating film.
- 15 2. A semiconductor device as set forth in claim 1,  
wherein the third insulating film comprises a  
phosphosilicate glass (PSG) film.
3. A semiconductor device as set forth in claim 1,  
wherein the third insulating film comprises a  
20 borophosphosilicate glass (BPSG) film.
4. A semiconductor device as set forth in claim 1,  
wherein the semiconductor layer comprises polysilicon.
5. A semiconductor device as set forth in claim 1,  
further comprising:
  - 25 a second conductivity type collector region

formed at the surface layer of a first conductivity type semiconductor substrate;

a first conductivity type base region formed at the surface layer of the second conductivity type

5 collector region;

a second conductivity type emitter region formed at the surface layer of the first conductivity type base region;

a first opening formed at least on the second  
10 conductivity type emitter region in the first insulating film;

a base electrode comprising the semiconductor layer formed in the first opening and on the first insulating film around the first opening;

15 a second opening formed in the base electrode and second, third, and fourth insulating films in the first opening; and

an emitter take-out part comprising a second semiconductor layer formed in the second opening and on  
20 the fourth insulating film around the second opening.

6. A semiconductor device as set forth in claim 1, further comprising:

a second conductivity type base region formed at the surface layer of the first conductivity type

25 semiconductor substrate;

a first conductivity type collector region formed at the surface layer of the second conductivity type base region;

5 a first conductivity type emitter region formed at the surface layer of the second base region separate from the first conductivity type collector region;

a collector opening formed in the first insulating film on the first conductivity type collector region;

10 an emitter opening in the first insulating film on the first conductivity type emitter region;

a collector take-out electrode comprising the semiconductor layer formed in the collector opening and on the first insulating film around the collector opening;

15 an emitter take-out electrode comprising the semiconductor layer formed in the emitter opening and on the first insulating film around the emitter opening;

a contact hole formed in the first, second, third, and fourth insulating films formed on the second conductivity type base region; and

a base electrode formed at the contact hole.

7. A semiconductor device as set forth in claim 1, further comprising:

25 a second conductivity type impurity diffusion

layer formed at the surface layer of the first conductivity type semiconductor substrate;

5 a first conductivity type collector region formed at the surface layer of the second conductivity type impurity diffusion layer;

a second conductivity type base region formed at the surface layer of the first conductivity type collector region;

10 a first conductivity type emitter region formed at the surface layer of the second conductivity type base region;

a collector opening formed in the first insulating film on the first conductivity type collector region;

15 an emitter opening formed in the first insulating film on the first conductivity type emitter region;

20 a collector take-out electrode comprising the semiconductor layer formed in the collector opening and on the first insulating film around the collector opening;

an emitter take-out electrode comprising the semiconductor layer formed in the emitter opening and on the first insulating film around the emitter opening;

25 a contact hole formed in the first, second,

third, and fourth insulating films on the second conductivity type base region; and

a base electrode formed at the contact hole.

8. A semiconductor device as set forth in claim 1,  
5 further comprising:

a first conductivity type collector region formed in the semiconductor substrate of the first conductivity type comprising a collector take-out part , connected to the surface of the semiconductor substrate;

10 a second conductivity type base region formed on the first conductivity type collector region except the collector take-out part;

a second conductivity type base region formed on the first conductivity type collector region except  
15 the collector take-out part;

a first conductivity type emitter region formed at the surface layer of the second conductivity type base region;

a collector opening formed in the first  
20 insulating film on the collector take-out part;

an emitter opening formed in the first insulating film on the first conductivity type emitter region;

a collector take-out electrode comprising the  
25 semiconductor layer formed in the collector opening and

on the first insulating film around the collector opening;

an emitter take-out electrode comprising the semiconductor layer formed in the emitter opening and on  
5 the first insulating film around the emitter opening;

a contact hole formed in the first, second, third, and fourth insulating films on the second conductivity type base region; and

a base electrode formed at the contact hole.

10 9. A semiconductor device as set forth in claim 1, further comprising:

a lower electrode layer formed at the surface layer of the semiconductor substrate;

15 an opening formed in the first insulating film on the lower electrode layer;

a capacitor dielectric layer formed in the opening and on the first insulating film around the opening;

20 an upper electrode comprising the semiconductor layer and formed on the capacitor dielectric layer;

a contact hole formed in the second, third, and fourth insulating films on the upper electrode; and

an interconnection formed at the contact hole.

25 10. A semiconductor device as set forth in claim 1, further comprising:

a resistor layer comprised of the semiconductor layer formed on the first insulating film;

a contact hole formed in the second, third, and fourth insulating films on the resistor layer; and

5 an interconnection formed at the contact hole.

11. A process of production of a semiconductor device comprising the steps of:

forming a first insulating film on a semiconductor substrate;

10 forming a semiconductor layer on the first insulating film;

forming a second insulating film comprising a non-doped silicon oxide film on the semiconductor layer;

forming a third insulating film comprising a silicon oxide film containing at least phosphorus on the second insulating film; and

forming a fourth insulating film comprising a non-doped silicon oxide film on the third insulating film.

20 12. A process of production of a semiconductor device as set forth in claim 11, wherein the step of forming the second, third, and fourth insulating films comprises three different chemical vapor deposition (CVD) steps.

25 13. A process of production of a semiconductor

device as set forth in claim 11, wherein the step of forming the second, third, and fourth insulating films comprises a continuous chemical vapor deposition process where a supply amount of phosphorus is changed before and  
5 after the step of forming the third insulating film.

14. A process of production of a semiconductor device as set forth in claim 11, further comprising the steps of:

forming a second conductivity type collector  
10 region at the surface layer of the semiconductor substrate of the first conductivity type;

forming a first conductivity type base region at the surface layer of the second conductivity type collector region;

15 forming the first insulating film on the semiconductor substrate and forming a first opening in the first insulating film;

forming a base electrode comprising the semiconductor layer in the first opening and on the first  
20 insulating film around the first opening;

forming the second, third, and fourth insulating films on the base electrode and the first insulating film around the base electrode;

forming a second opening in the base electrode  
25 and the second, third, and fourth insulating films in the

first opening;

forming an emitter take-out part comprising a second semiconductor layer in the second opening and on the fourth insulating film around the second opening; and

5 diffusing an impurity from the emitter take-out part and forming a second conductivity type emitter region at the surface layer of the first conductivity type base region.

15. A process of production of a semiconductor  
10 device as set forth in claim 11, further comprising the steps of:

forming a second conductivity type base region at the surface layer of the semiconductor substrate of the first conductivity type;

15 forming the first insulating film on the semiconductor substrate and forming a collector opening and emitter opening in the first insulating film;

forming the semiconductor layer in the collector opening and emitter opening and on the first  
20 insulating film;

etching the semiconductor layer and forming a collector take-out electrode comprising the semiconductor layer in the collector opening and on the first insulating film around the collector opening;

25 forming by the etching an emitter take-out

electrode comprising the semiconductor layer in the emitter opening and on the first insulating film around the emitter opening;

forming the second, third, and fourth  
5 insulating films on the collector take-out electrode, emitter take-out electrode, and first insulating film around the emitter take-out electrode and the collector take-out electrode;

diffusing an impurity from the collector take-  
10 out electrode and forming a first conductivity type collector region at the surface layer of the second conductivity type base region;

diffusing an impurity from the emitter take-out  
electrode and forming a first conductivity type emitter  
15 region at the surface layer of the second conductivity type base region;

forming a contact hole in the first, second, third, and fourth insulating films on the second conductivity type base region; and

20 forming a base electrode at the contact hole.

16. A process of production of a semiconductor device as set forth in claim 11, further comprising the steps of:

forming a second conductivity type impurity  
25 diffusion layer at the surface layer of the semiconductor

substrate of the first conductivity type;

forming a first conductivity type collector region at the surface layer of the second conductivity type impurity diffusion layer;

5 forming a second conductivity type base region at the surface layer of the first conductivity type collector region;

forming the first insulating film on the semiconductor substrate;

10 forming a collector opening in the first insulating film on the first conductivity type collector region and forming an emitter opening in the first insulating film on the second conductivity type base region;

15 forming the semiconductor layer in the collector opening and emitter opening and on the first insulating film;

forming a collector take-out electrode comprising the semiconductor layer in the collector opening and on the first insulating film around the collector opening;

20 forming an emitter take-out electrode comprising the semiconductor layer in the emitter opening and on the first insulating film around the emitter opening;

25

forming the second, third, and fourth  
insulating films on the collector take-out electrode,  
emitter take-out electrode, and first insulating film  
around the collector take-out electrode and emitter take-  
5 out electrode;

diffusing an impurity from the collector take-  
out electrode and forming a collector take-out part at  
the surface layer of the first conductivity type  
collector region;

10 diffusing an impurity from the emitter take-out  
electrode and forming a first conductivity type emitter  
region at the surface layer of the second conductivity  
type base region;

forming a contact hole in the first, second,  
15 third, and fourth insulating films on the second  
conductivity type base region; and

forming a base electrode at the contact hole.

17. A process of production of a semiconductor  
device as set forth in claim 11, further comprising the  
20 steps of:

forming a first conductivity type collector  
region in the semiconductor substrate of the first  
conductivity type;

forming a second conductivity type base region  
25 in a part of the semiconductor substrate on the first

conductivity type collector region;

forming the first insulating film on the semiconductor substrate;

forming a collector opening in the first  
5 insulating film on the first conductivity type collector region and forming an emitter opening in the first insulating film on the second conductivity type base region;

forming the semiconductor layer in the  
10 collector opening and emitter opening and on the first insulating film;

forming a collector take-out electrode comprising the semiconductor layer in the collector opening and on the first insulating film around the  
15 collector opening;

forming an emitter take-out electrode comprising the semiconductor layer in the emitter opening and on the first insulating film around the emitter opening;

20 forming the second, third, and fourth insulating films on the collector take-out electrode, emitter take-out electrode, and first insulating film around the collector take-out electrode and emitter take-out electrode;

25 diffusing an impurity from the collector take-

out electrode to form a collector take-out part at the surface layer of the first conductivity type collector region;

diffusing an impurity from the emitter take-out  
5 electrode to form a first conductivity type emitter region at the surface layer of the second conductivity type base region;

forming a contact hole in the first, second,  
third, and fourth insulating films on the second  
10 conductivity type base region; and

forming a base electrode at the contact hole.

18. A process of production of a semiconductor device as set forth in claim 11, further comprising the steps of:

15 forming a lower electrode layer at the surface layer of the semiconductor substrate;

forming the first insulating film on the semiconductor substrate and forming an opening in the first insulating film on the lower electrode layer;

20 forming a capacitor dielectric layer in the opening and on the first insulating film around the opening;

forming an upper electrode comprising the semiconductor layer on the capacitor dielectric layer;

25 forming the second, third, and fourth

insulating films on the upper electrode and first  
insulating film around the upper electrode;

forming a contact hole in the second, third,  
and fourth insulating films on the upper electrode; and

5 forming an interconnection at the contact hole.

19. A process of production of a semiconductor  
device as set forth in claim 11, further comprising the  
steps of:

after forming the semiconductor layer on the  
10 first insulating film, diffusing an impurity to the  
semiconductor layer;

etching the semiconductor layer and forming a  
resistor layer comprising the semiconductor layer;

forming the second, third, and fourth  
15 insulating films on the resistor layer and the insulating  
film around the resistor layer;

forming a contact hole in the second, third,  
and fourth insulating films on the resistor layer; and

forming an interconnection at the contact hole.